P01MED005EP

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 615 263 A1

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 94103333.4

(51) Int. Cl.[5]: H01H 1/02, H01H 33/66

(22) Date of filing: 04.03.94

(30) Priority: 11.03.93 JP 50776/93

(43) Date of publication of application: 14.09.94 Bulletin 94/37

(84) Designated Contracting States: DE FR

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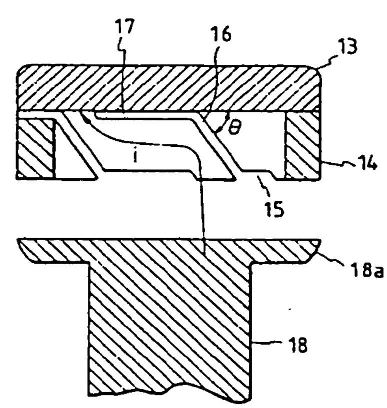
(54) **Vacuum circuit-breaker, electrode assembly for vacuum circuit-breaker, and manufacturing method thereof.**

(57) For the electrode of a vacuum circuit-breaker, a part of a high-conductive metal member is infiltrated in voids of a porous high-melting metal member, and both metal members are integrally joined to each other. An arc electrode portion 13 is formed of a high-melting area in which the high-conductive metal is infiltrated in voids of the high-melting metal member. A coil electrode portion 14 is formed by hollowing the interior out of a high-conductive metal area, which is composed of only the high-conductive metal, and forming of slits (15...17) therein. A rod 18 is hard-brazed on the rear surface of the coil electrode portion 14. With this electrode, it is possible to reduce the number of parts and to omit the brazing portion between the arc electrode portion 13 and the coil electrode portion 14, thus lowering the electric resistance and the heat generated in operation.

FIG. 1



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FIELD OF THE INVENTION

The present invention relates to a vacuum circuit-breaker, an electrode assembly for a vacuum circuit-breaker, and a manufacturing method thereof, and Particularly to an electrode composed of an arc electrode portion and a coil electrode portion.

BACKGROUND OF THE INVENTION

In general, a vacuum circuit-breaker for a large current is so constructed that a pair of separable electrodes are disposed in a vacuum vessel, and rods connected to the rear surfaces of these electrodes extend to the outside of the vacuum vessel. Each of a pair of the above electrodes is composed of an arc electrode portion on the front surface side and a coil electrode portion on the rear surface side which are opposed to each other. A current flows from one rod to the other rod by way of the coil electrode portion and the arc electrode portion of one electrode, and the arc electrode portion and the coil electrode portion of the other electrode. For breaking the current, any one of the rods is moved by an operating device so as to separate the arc electrode portion of one electrode from the arc electrode portion of the other electrode. At this time, an arc is generated between both the arc electrode portions. This arc is dispersed in the filiform manner by magnetic field generated in the axial direction, that is, in parallel to the arc by the current flowing in the above coil electrode, to be extinguished.

Incidentally, for example, as disclosed in Japanese Patent Laid-open No. SHO 62-103928 (USP 4,704,506), the prior art electrode of this type which is composed of the arc electrode portion and the coil electrode portion is so constructed as follows: Namely,at least the portion contacted with an arc in the arc electrode portion is formed by the step of machining such as cutting a metal member excellent in withstand voltage performance and current-breaking performance, for example, obtained by infiltration of a high conductive metal such as copper in voids of a high melting point metal such as chromium. Futher, the coil electrode portion is formed by the step of machining such as cutting inclined or circumferential slits on the side surface of a cylindrical member made from a high conductive metal such as copper, wherein the above slitted portion is adapted to allow a current to flow therethrough in the circumferential direction. These arc electrode portion and the coil electrode portion, and the coil electrode portion and the rod are electrically and mechanically connected to each other by hard brazing such as silver brazing, respectively.

SUMMARY OF THE INVENTION

In the above prior art electrode, the arc electrode portion, the coil electrode portion and the rod are separately manufactured, and they are integrally assembled with each other by hard brazing. Accordingly, the prior art has the following disadvantages: namely, the number of parts is increased to thereby raise the cost, and the electric resistance of the brazing portion between the respective members is increased to thereby enlarge the calorific value during current-carrying, which requires the measure such as provision of a hear releasing portion, to thereby enlarge the size as a whole.

Accordingly, an object of the present invention is to provide an electrode for a vacuum circuit-breaker which is capable of reducing a cost, lowering the electric resistance, and making smaller the size, and its manufacture, and further, a vacuum circuit-breaker including the same electrodes.

To achieve the above object, the present invention is characterized in that a part of a high conductive metal member is infiltrated in voids of a porous high melting point metal member, and both the metal members are integrally joined to each other; the arc electrode portion is formed of a high melting point metal ares in which the high conductive metal is infiltrated in voids of the high melting point metal member; and the coil electrode portion is formed of a high conductive metal area composed of only the high conductive metal.

Further, the present invention is characterized by superposing a high conductive metal member on a porous high melting point metal member formed by compressing and sintering of a high melting point metal powder; heating and fusing at least a part of the high conductive metal member on the side connected with the high melting point metal member for infiltrating it in voids of the high melting point metal member, thereby integrally joining both the metal members to each other; machining a high melting point metal area in which the high conductive metal is infiltrated in voids of the high melting point metal member to form the arc electrode portion; forming a high conductive metal area composed of only the high conductive metal approximately in a cylindrical shape by hollowing the interior thereof through machining, and providing inclined or circumferntial slits on the side surface of the cylinder, thereby forming the coil electrode portion; and connecting the rod on the rear surface of the coil electrode portion.

In the present invention, since a part of a high conductive metal member is infiltrated in voids of a porous high melting point metal member, and they are integrally joined to form one metal block. An arc electrode portion and a coil electrode portion

are formed of such metal block. Accordingly, it is possible to reduce the number of parts, to omit the brazing portion between the arc electrode portion and the coil electrode portion resulting in the reduced electric resistance, thereby lowering the calorific value during current-carrying.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention are now described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of an electrode showing one embodiment of the present invention;

Figure 2 is an explanatory view showing a method of manufacturing an electrode material of the present invention;

Figure 3 is an explanatory view showing a method of manufacturing an electrode of the present invention;

Figure 4 is a sectional view of a vacuum circuit-breaker to which the present invention is applied;

Figures 5 and 6 are sectional views of electrodes showing other embodiments of the present invention; and

Figure 7 is a plan view of an electrode showing a further embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, one embodiment of the present invention will be described with reference to Figs. 1 to 4.

Fig. 4 is a sectional view of a vacuum circuit-breaker to which the present invention is applied, wherein end plates 2A and 2B are mounted at both ends of an insulating cylinder 1, to form a vacuum vessel 3. A pair of a fixed electrode 4 and a movable electrode 5 are oppositely disposed in the vacuum vessel 3. Rods 6 and 7 respectively connected to the rear surfaces of the electrodes 4 and 5 extend to the outside of the vacuum vessel 3. A bellows 8 is mounted between the movable side rod 7 and the end plate 2B. The movable side rod 7 is connected to an operating device (not shown). The movable side rod 7 is moved by this operating device, so that the movable electrode 5 is electrically contacted with or separated from the fixed electrode 4.

Each of both the electrodes 4 and 5 includes an arc electrode portion and a coil electrode portion, which are integrated with each other. In addition, the coil electrode portion may be included in at least one of both the electrodes 4 and 5.

The material for these electrodes is manufactured by such a method as shown in Figs. 2 and 3. First, as shown in Fig. 2, a powder of a high melting point such as chromium or tungsten, or added with a powder of copper is filled in a vessel 22, which is compressed to obtain a specified porosity. This compressed powder is sintered, to form a porous high melting point metal member 9. A metal member 10 having a high conductivity such as copper or copper alloy is placed on the above high melting point metal member 9, and heated and fused, to be thus infiltrated in voids of the high melting point metal member 9. In this case, when the amount of the high conductive metal member 10 is larger than the volume of voids of the high melting point metal member 9, as shown in Fig. 3, there are formed a high melting point metal area 11 excellent in withstand voltage performance and current-breaking performance in which the high conductive metal is infiltrated in the voids of the high melting point metal member 9, and a high conductive metal area 12 formed of only the remaining high conductive metal not infiltrated in the voids of the high melting point metal member 9, which are integrally joined to each other.

In addition, the infiltration of the high conductive metal member 10 in the voids of the high melting point metal member 9 is performed by use of the dead weight of the high conductive metal member 10; however, in the case that the infiltration is difficult, the high conductive metal member 10 may be applied with a pressure from the upper side.

Further, in this embodiment, the high conductive metal member 10 is wholly heated and fused; however, it may be heated and fused only on its necessary portion on the side contacted with the high melting point metal member 9.

By use of one metal block composed of the high melting point metal area 11 and the high conductive metal area 12 which are integrally joined to each other, as shown in Fig. 1. an arc electrode portion 13 and a coil electrode portion 14 are respectively formed of the high melting point metal area 11 and the high conductive metal area 12 by a known prior art machining. Namely, the high melting point metal area 11 is cut in a specified shape, to form the arc electrode portion 13. Further, the high conductive metal area 12 is formed approximately in a cylindrical shape by hollowing of the interior there of through cutting, which is cut with circumferential slits 15 and 17 and inclined slits 16, to thus form the coil electrode portion 14. On the rear surface of the coil electrode portion 14, a rod 18 including a flange portion 18a with the same diameter as that of the electrode is hard-brazed in the conventional manner.

In the electrode for a vacuum circuit-breaker having the above construction, a current i flows from the rod 18 along portions defined by respective slits 15 to 17 of the coil electrode portion 14 in the circumferential direction, to generate a magnetic field in the axial direction, that is, approximately in parallel to the arc as a whole of the coil electrode portion 14.

Additionally, the number of the slits is suitably selected in consideration of the diameter of the electrode and the magnitude of the breaking current. Further, the shape of the slit is not limited to the above embodiment. For example, by making smaller the inclination angle θ of the inclined slit 16, the same effect can be obtained even if the circumferential slits 15 and 17 are omitted.

Fig. 5 shows another embodiment of the present invention. In this embodiment, the material for the electrode is the same as in the above embodiment, but the machining method for the coil electrode portion 14 is different. Namely, in the case that the high conductive metal area 12 is formed approximately in the cylindrical shape by hollowing of the interior thereof through cutting, a diameter D1 of an opening portion 19 on the rear surface of this cylinder is made smaller than a diameter D2 of the rod 18. After that, slits are formed by cutting, and a small stepped portion 18b of the rod 18 is inserted in the opening portion 19, to be hard-brazed in the conventional manner.

To provide the flange 18a on the rod 18 as described in the embodiment in Fig. 1, for exampled, it is required to strike the end portion of the rod 18 and swell the end portion up to the diameter of the flange portion 19a, or to separately prepare the flange portion 18a and join it to the rod 18, which takes a lot of labor.

However, in the case that the opening portion 19 with the diameter smaller than that of the rod 18 is formed on the rear surface of the coil electrode portion 14 as in this embodiment, only the small diameter stepped portion 18 is formed at the end portion of the rod 18 by cutting, which makes easy the manufacture.

Fig. 6 shows a further embodiment of the present invention. In this embodiment, in the case that the high conductive metal area 12 is formed approximately in a cylindrical shape by hollowing of the interior thereof through cutting, the portion contacted with the rear surface of the arc electrode portion 13 is made to remain by a suitable thickness as a backing electrode portion 20. The other construction is the same as in the embodiment in Fig. 5.

According to this embodiment, even in the case that the conductivity of the arc electrode portion 13 is low, a current is allowed to sufficiently flow from the circumferential portion of the coil electrode portion 14 to the central portion of the arc electrode portion 13 through the backing electrode portion 20 made from a high conductive metal. Accordingly, it is possible to equivalently increase the conductivity of a current path directed from the circumferential portion of the coil electrode portion 14 to the central portion of the arc electrode portion 13.

In addition, in the case that the backing electrode portion 20 with high conductivity is provided on the rear surface of the arc electrode portion 13 particularly as in the embodiment of Fig. 6, an eddy current tends to flow at these portions, and a part of the axial magnetic field generated by the coil electrode portion 14 is cancelled by the eddy current, thereby causing a fear that the magnetic field necessary for ensuring the current breaking performance can not be obtained.

In such a case, as shown in Fig. 7, a plurality of slits 21 radially extending from the center area of the ellctrode may be provided by cutting from the surface of the arc electrode portion 13 to the backing electrode portion 20. This makes it possible tc reduce the generation of the eddy current, and hence to effectively utilize the axial magnetic field generated at the coil electrode portion 14.

In the prior art electrode in which the arc electrode portion, the coil electrode portion, the backing electrode portion and the like are integrally joined to each other by brazing, if the slits for reducing the eddy current as described above is provided,the brazing material at the joining portion is exposed from the front surface side, which causes a fear that the brazing material touches the arc. Consequently, since the brazing material is low in its melting point, and also is low in the withstand voltage performance and current breaking performance, the withstand voltage performance and the current breaking performance of the electrode is lowered. Accordingly, the prior art electrode cannot be provided with such slits for reducing the eddy current.

However, in the electrode of this embodiment, the arc electrode portion, the coil electrode portion, the backing electrode portion are formed of an integral metal block, and accordingly, they are not brazed. As a resuly, even if the slits for reducing the eddy current are provided, it is possible to eliminate the lowering of the withstand voltage performance and the current breaking performance of the electrode due to exposure of the brazing material, and hence to freely provide the slits for reducing the eddy current.

Additionally, in the case that a vacuum circuit-breaker comprises the electrode construction as shown in each embodiment described above, there is a fear that the strength of the material of the ccoil electrode portin is weak and the slits are

broken, which leads to the short-circuit. In this case, an insulating material with a large mechanical strength, or a spacer made from a metal with a electric resistance higher than the coil electrode portion such as stainless steel may be interposed between the arc electrode portion and the rod, or between the backing electrode portion (if it exists) and the rod.

As described above, according to the present invention, a part of a high conductive metal member is infiltrated in voids if a porous high melting point metal member. and they are integrally joined to each other, to thus form one metal block; and an arc electrode portion and a coil electrode portion are formed of the one metal block. Accordengly, it is possible to reduce the number of parts and manufacture the electrode at a low cost, to omit the brazing portion between the arc electrode portion and the coil electrode portion resulting in the reduced electric resistance, and to reduce the calorific value in current-carrying without providing the heat releasing portion.

Claims

1. A vacuum circuit-breaker, comprising:
   a vacuum vessel (3),
   a pair of separable electrodes (4, 5) disposed in said vacuum vessel (3), and
   rods (6, 7) connected to the rear surfaces of said electrodes (4, 5) and extending to the outside of said vacuum vessel (3),
   wherein at least one of said electrodes comprises an arc electrode portion (13) positioned on the front surface side, and a coil electrode portion (14) positioned on the rear surface side for generating a magnetic field approximately in parallel to the arc by a current flowing therethrough,
   characterised in
   that said at least one electrode (4, 5) is formed of a high-conductive metal member (10), and a porous high-melting metal member (9), wherein part of said high-conductive metal member (10) is infiltrated in voids of said porous high-melting metal member (9), and both said metal members are integrally joined to each other by the infiltration,
   that said arc electrode portion (13) is formed of a high-melting metal area (11) in which said high-conductive metal is infiltrated in voids of said high-melting metal member (9), and
   said coil lectrode portion (14) is formed of a high-conductive metal area (12) composed of said high-conductive metal member (10).

2. An electrode for a vacuum circuit-breaker, comprising
   an arc electrode portion (13) constituting the front side of the electrode, and
   a coil electrode portion (14) constituting the rear side of the electrode,
   characterised in that said arc electrode portion (13) is formed of a high-melting metal area (11) of a metal block in which high-conductive metal (10) is infiltrated in voids of a porous high-melting metal member (9), and
   that said coil electrode portion (14) is formed of a high-conductive metal area (12) composed of said high-conductive metal (10).

3. The electrode of claim 2,
   wherein said high-conductive metal area (12) is of a substantially hollow-cylindrical shape with inclined and/or circumferential slits (15...17) provided on the cylinder side surface, to form said coil electrode portion (14), and
   wherein the sectional area of an opening (19) provided in the rear side of said cylinder is smaller than that of the hollow interior of said cylinder, a stepped tip (18b) of an electrode rod (18) being inserted in said opening (19) and connected therewith.

4. The electrode of claim 2, wherein said high-conductive metal area (12) is of a substantially hollow-cylindrical shape with the portion connected to said arc electrode portion (13) remaining as a backing electrode portion (20), and
   wherein inclined and/or circumferential slits (15...17) are provided on the side surface of said cylinder, to form said coil electrode portion (14).

5. The electrode of claim 4, wherein radially extending slits (21) are provided within said arc electrode portion (13) and/or said backing electrode portion (20).

6. A method of manufacturing an electrode assembly for a vacuum circuit-breaker including an arc electrode portion (13) positioned on the front surface side, a coil electrode portion (14) positioned on the rear surface side for generating a magnetic field substantially parallel to the arc by a current flowing through said coil electrode portion (14), and a rod (18) connected to the rear surface of said coil electrode portion (14), comprising the steps of:
   superposing a high-conductive metal member (10) on a porous high-melting metal member (9) formed by compressing and sintering high melting metal powder,

heating and fusing at least part of said high-conductive metal member (10) on the side connected to said high-melting metal member (9) for infiltrating the high-conductive metal in voids of said high-melting metal member (9), thereby integrally joining both metal members to each other,

machining a high-melting metal area (11) in which said high-conductive metal is infiltrated in voids of said high-melting metal member (9) to form said arc electrode portion (13),

forming a high conductive metal area (12) composed of only said high conductive metal into a substantially cylindrical shape by hollowing the interior through machining, and providing inclined and/or circumferential slits (15...17) on the side surface of said cylinder, thereby forming said coil electrode portion (14), and

connecting said rod (18) to the rear surface of said coil electrode portion (14).

FIG. 1

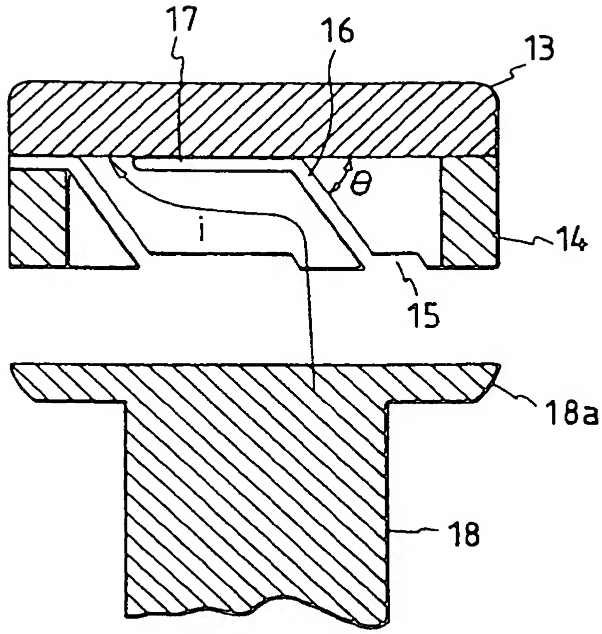


FIG. 2

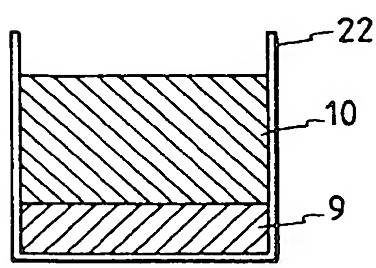


FIG. 3

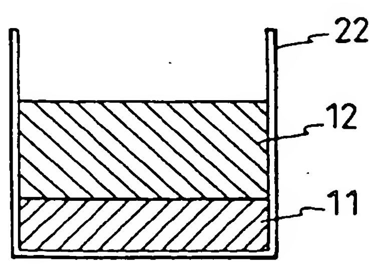


FIG. 4

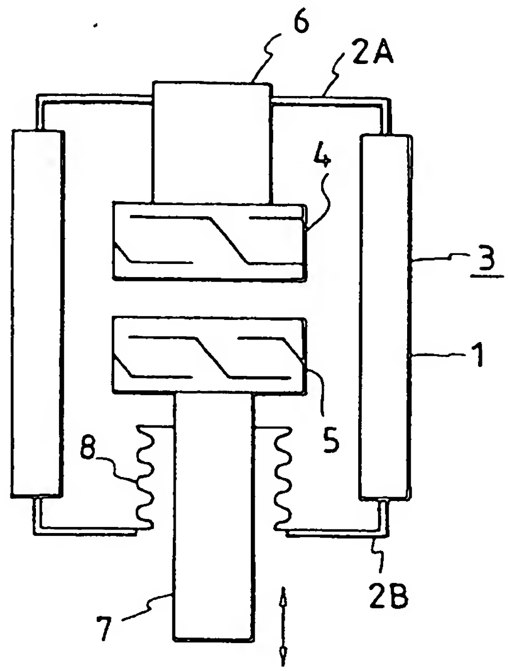


FIG. 5

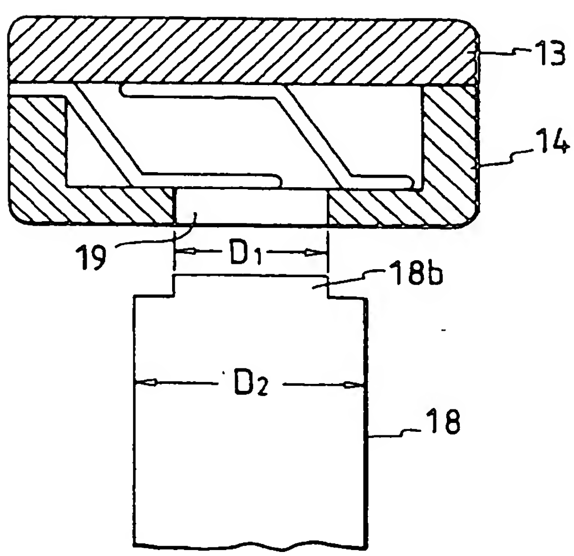


FIG. 6

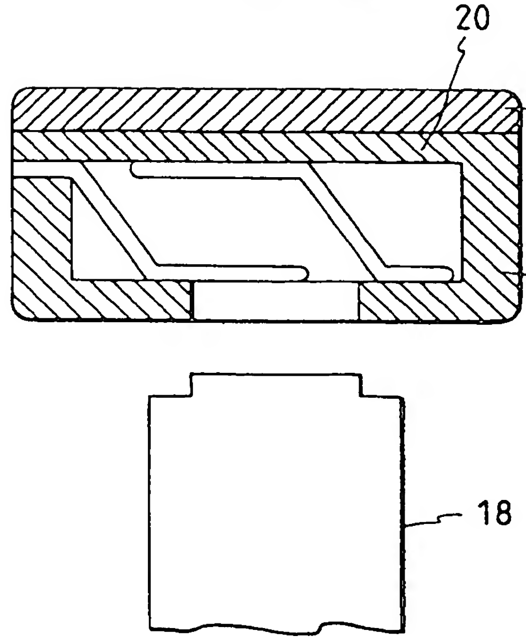
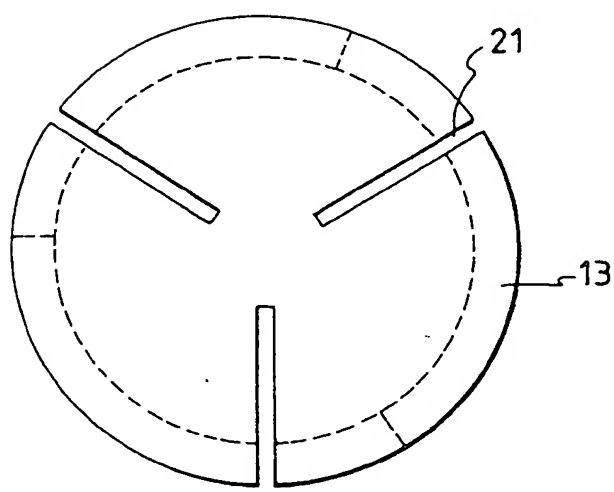


FIG. 7



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EUROPEAN SEARCH REPORT

Application Number
EP 94 10 3333

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	DE-A-18 05 865 (SIEMENS) * claims; figure 1 *	1	H01H1/02 H01H33/66
A	DE-A-31 30 466 (CALOR-EMAG) * abstract; claim 1; figures *	1	
A	EP-A-0 155 322 (HITACHI) * abstract; figures *	1	
D,A	EP-A-0 208 271 (HITACHI) * abstract; figure 2 *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 June 1994	Janssens De Vroom, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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